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Heat exchanger, especially gas cooler

The invention relates to a heat exchanger, especially a gas cooler for a CO₂ coolant circuit of a motor vehicle air conditioning system, according to the preamble of patent claim 1.

Heat exchangers for air conditioning systems with R134a as the coolant, for example condensers, are composed of a heat transfer network with flat tubes and collecting tubes which are arranged on each side of the network and have a circular cross section or some other cross section. Other heat exchangers for air conditioning systems, for example two-row evaporators according to DE-A 198 26 881 by the applicant, have a collecting box which is divided into two longitudinal chambers and which is manufactured from a prepared sheet metal plate by bending the edge regions of the sheet metal plate. In this way, a central, double-layered longitudinal dividing wall is obtained and is secured in cutouts in the flat bottom of a collecting box by means of tongues. Two rows of passages for the two rows of flat tubes are arranged in the bottom, that is to say each longitudinal chamber communicates with a row of flat tubes. This design already provides a relatively high level of compressive strength. In modern air conditioning systems which use CO₂ (R744) as the coolant there are, however, relatively high pressures which are multiplied by approximately 10 and can no longer be coped with using the conventional designs for heat exchangers. For this reason, extruded collecting tubes with an increased wall strength have been proposed in WO 98/51 983, a collecting tube being composed of four circular flow ducts which are arranged one next to the other. Owing to the tools which are required for this, such an extruded collecting tube is costly to manufacture.

Another type of collecting tube has been proposed in DE-A 199 06 289, with a collecting tube being constructed of two or three extruded or pressed components and having two circular flow ducts for the coolant (CO₂). With this design also it is necessary for at least part of the collecting tube to be manufactured by extrusion or some other costly shaping method, which usually has an unfavorable effect on the manufacturing costs of the heat exchanger, for example the gas cooler.

The object of the present invention is therefore to improve a heat exchanger of the type mentioned at the beginning to the effect that the collecting box has a high degree of strength with a low weight and can be manufactured cost-effectively.

This object is achieved by means of the features of patent claim 1.

As is known from the prior art (DE-A 198 26 881) which is mentioned at the beginning, the collecting box is formed in one piece and is bent out of a sheet metal strip in such a way that two longitudinal ducts are produced which are, however, fluidically connected, in contrast to this prior art, only to one row of flat tubes. This design of the collecting box permits an approximately circular cross section and thus a pressure-resistant collecting box. The double-layered longitudinal dividing wall is secured and anchored in a central region of the sheet metal strip by means of tongues, which facilitate fabrication and increases the strength.

According to one advantageous development of the invention, the tongues for securing the longitudinal dividing wall may be arranged either on the side facing the flat tubes or on the side facing away from the flat tubes. This increases the configuration possibilities

of the heat exchanger.

According to one advantageous development of the invention, notches in which the flat tube ends engage
5 are formed in the longitudinal dividing wall, in the region of the flat tube ends which project into the longitudinal ducts. As a result, the flat tubes can be pushed into the collecting box by a relative distance, approximately as far as the center, and formed at a
10 maximum depth (the depth of the flat tube is measured in the direction of air flow). The collecting box is deeper than the flat tube only to an insignificant degree. This advantageously provides space for shaped portions or passages.

15 In a further advantageous embodiment of the invention, gaps, which may be formed, for example, in a U shape or be arranged only to the side of the flat tube or above it, are left between the notches and the flat tube
20 ends. It is advantageous here if the notches serve simultaneously as a stop for the flat tubes when the latter are pushed into the collecting box through the slot-shaped openings. This results in precise positioning for the flat tubes in the collecting box.
25 The gaps permit pressure and flow to be equalized between the two longitudinal ducts which are arranged one next to the other.

According to a further advantageous embodiment of the invention, the region of the collecting box in which
30 the cutouts are arranged with the tongues can be stepped back somewhat toward the interior, i.e. in the direction of the longitudinal dividing wall, as a result of which a certain degree of "cutting to size"
35 of the cross section of the collecting box is carried out. This ensures that the cross sections of the longitudinal ducts are approximated even more, i.e. beyond 270 degrees circumference, to a circular cross section which then fits the strength and the weight.

Finally, it may also be advantageous to form the cross sections of the two longitudinal ducts so that they are not the same but rather different, and at the same time the dividing wall can be positioned off-center, i.e. asymmetrically. An essential feature for the configuration of the collecting box is that the tongues are arranged approximately at right angles to the connecting strip with the cutouts in order to bring about an optimum tie rod effect.

Exemplary embodiments of the invention are illustrated in the drawing and will be described in more detail in the text which follows. In the drawing:

- fig. 1 is a perspective partial view of a gas cooler,
- fig. 2 shows a section through the gas cooler according to fig. 1,
- fig. 3 shows a section along the line III-III in fig. 2,
- fig. 4 shows a second exemplary embodiment of a gas cooler,
- fig. 5 shows a section through the gas cooler according to fig. 4,
- fig. 6 shows a section along the line VI-VI in fig. 5, and
- fig. 7 shows a third exemplary embodiment of a gas cooler in section.

Fig. 1 shows a detail of a gas cooler 1 with a collecting box 2 and flat tubes 3 which open with their flat tube ends 3a into the collecting box 2 and are accommodated in slot-shaped openings 4. Corrugated ribs for enlarging the air-side heat transfer face are provided between the flat tubes 3, and are not illustrated. The gas cooler 1 is suitable in particular for use in a coolant circuit with CO₂ as a coolant of a motor vehicle air conditioning system but is not

restricted to this application. Gaseous CO₂ flows through the gas cooler on the primary side, i.e. in the collecting boxes and the flat tubes, at a pressure of approximately 120 bar and ambient air is applied to it on the secondary side; said gas cooler has the function of cooling the CO₂ gas from a temperature of approximately 150 degrees Celsius to 50 degrees Celsius. The pressure which occurs in this context is approximately ten times that of conventional condensers in a circuit with the coolant R134a.

Fig. 2 shows the gas cooler 1 according to fig. 1 in a section, the construction of the collecting box 2 clearly being in one piece. Said collecting box 2 has two longitudinal chambers 5, 6 which are divided from one another by a double longitudinal dividing wall 7. The collecting box 2 is manufactured from a sheet metal plate or a sheet metal strip 8 which has external edge strips or longitudinal edges 9, 10 which are provided with tongues 11, 12. Cutouts 13 are arranged in the center of the sheet metal strip 8 in a way which corresponds to the arrangement of the tongues 11, 12.

The collecting box 2 is manufactured from the sheet metal strip 8 which has been prepared, i.e. cut to size and punched out, in such a way that the sides with the longitudinal edges 9, 10 are bent over to form approximately cylindrical ducts 5, 6 and that the longitudinal edges 9, 10 are moved back to the center, approximately perpendicularly to a central connecting region 14 where they are plugged into the cutouts 13 by means of the tongues 11, 12. As a result the longitudinal edges 9, 10 are secured and the collecting box 2 is ready for the soldering process. The flat tubes 3 are plugged by their flat tube ends 3a into the openings 4 and project with their upper edge 3b approximately halfway into the free cross section of the longitudinal ducts 5, 6. Since the cross section of the longitudinal ducts 5, 6 is at its maximum width

here, the cross section which tapers after this produces a stop for the flat tubes 3.

Fig. 3 shows a section through the gas cooler 1 in the
5 plane III-III in fig. 2. This section through the longitudinal duct 5 shows the dividing wall 7 which has U-shaped notches 15 in the region of the flat tube ends 3a. A gap 16 which clears a throughflow cross section between the two longitudinal ducts 5, 6 is left between
10 the contour of the flat tube ends 3a and the contour of the notch 15. Through this gap 16 it is possible, on the one hand, for the coolant also to emerge in the center of the flat tubes ends 3a, and, on the other hand, coolant can flow from one longitudinal duct 5
15 into the other longitudinal duct 6 and vice versa so that pressure equalization can take place between the two longitudinal ducts. The notches 15 and the gap shape 16 are indicated only in exemplary fashion in the drawing, and the shape of the gap can also be modified
20 in such a way that there is a gap only above the flat tube ends, i.e. above the upper edge 3b, or only to the side of the flat tube ends 3a. In the latter case, the upper edge 3b of the flat tube would abut against the notch in the dividing wall 7, which would result in a stop. The tongues 11, 12 protrude above the outer wall
25 of the collecting box 2 and are each arranged approximately centrally between two flat tubes 3. However, it is also possible to bridge one or more distances between flat tubes and to arrange the tongues
30 11, 12 and the cutouts 13 at any desired distances respectively between two flat tubes.

Fig. 4 shows a further exemplary embodiment of a gas cooler 20 with a collecting box 21 and flat tubes 22.
35 Tongues 23 and cutouts 24 are arranged here on the upper side of the collecting box 21, i.e. on the side facing away from the flat tubes 22.

Fig. 5 shows this gas cooler 20 in section. The

collecting box 20 is in principle of the same design as in the exemplary embodiment according to fig. 2 but mirror inverted. The collecting box 21 has two longitudinal chambers 21a, 21b which are divided from one another by a double longitudinal dividing wall 25. Flat tubes 22 are pushed into the collecting box 21 by an opening (not shown here) so that with their flat tube ends 22a they fill approximately half of the longitudinal ducts 21a, 21b. The upper edge 22b therefore lies at the height of the maximum width of the internal cross section. The flat tube 22 has a continuous depth t which extends into the collecting box 21.

Fig. 6 shows a section in the plane VI-VI through the longitudinal ducts 21a in fig. 5. The flat tubes 22 are inserted into collecting boxes 21 through corresponding openings 26, with the openings 26 extending over the full depth t of the flat tube 22. Approximately circular notches 27 are arranged above the upper edge 22b of the flat tube ends 22a, said notches 27 merging with the rectangular cross section corresponding to the flat tube cross section and thus permitting the flat tube ends 22a to be inserted. An approximately circular gap 28, which forms a passage cross section between the two longitudinal chambers 21a, 21b, is left above the upper edge 22b of the flat tube ends 22a. No gap is left directly next to the flat tube ends 22a. The tongues 23 and also the cutouts (not shown here) are also respectively arranged here between the flat tubes 22.

Fig. 7 shows a third exemplary embodiment of a gas cooler 30 with a collecting box 31 and flat tubes 32. A double longitudinal dividing wall 33 is anchored with tongues 34 in a central connecting region 35, with this connecting region 35 being stepped back somewhat toward the inside, i.e. offset inward by an amount x with respect to a lower boundary line 1 of the collecting

box 31. As a result, the cross sections of the longitudinal ducts 36, 37 are approximated to the circular shape beyond the three-quarter circle (270 degrees). Nevertheless, the set-back central connecting
5 region 35 and the double longitudinal dividing wall 33 form a right angle. This cross sectional shape thus provides a higher degree of compressive strength for the collecting box 31.

10 All the exemplary embodiments described above are suitable and advantageous for high internal pressures and thus also for a coolant circuit of a motor vehicle air conditioning system which is operated with CO₂.

List of reference numerals

	1	Gas cooler
	2	Collecting box
5	3	Flat tube
	4	Opening
	5	Longitudinal duct
	6	Longitudinal chamber
	7	Longitudinal dividing wall
10	8	Sheet metal strip
	9	Longitudinal edge
	10	Longitudinal edge
	11	Tongue
	12	Tongue
15	13	Cutout
	14	Central connecting region
	15	Notch, U-shaped
	16	Gap
	17	Gap
20	20	Gas cooler
	21	Collecting box
	21a	Longitudinal chamber
	21b	Longitudinal chamber
	22	Flat tubes
25	23	Tongue
	24	Cutout
	25	Longitudinal dividing wall
	26	Opening
	27	Notch
30	28	Gap
	30	Gas cooler
	31	Collecting box
	32	Flat tube
	33	Longitudinal dividing wall
35	34	Tongues
	35	Central connecting region
	36	Longitudinal duct
	37	Longitudinal duct
	38	Gap